UP TO YOU s.r.o.
Za Stanicou 10
831 04 Bratislava – SK

mail: info@uptoyou.sk

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Abstract

AWA – Modula Technology – Photovoltaic Cleaning Optimization

General Info on Technology

Airborne particle and pollution deposition on panels is a current issue that affects photovoltaic energy production to a very variable degree. Such a phenomenon strongly depends upon panel location and local pollution: the related energy loss can go from 3% up to 50% (or even more) of the expected efficiency

There are various mitigation approaches, and these are characterised by different efficiencies. One of the most diffused approach is panel cleaning, which is performable in many ways, as "preventative" (meaning it is based on special coating materials), "automatic" (carried out by means of machines and robots), and "manual" (labour driven).

Automatic and manual panel cleaning methods often require water use, but it is mandatory to verify water quality Employing demineralised water can be one of the best solutions [1,3] because it is effective and it avoids chemicals addition. Demineralised water is often recommended by panel cleaning robot manufacturers because it avoids nozzle clogging. Moreover, it must be noted that surfactants, salts, and other elements, when added to water for cleaning, can reduce the efficiency of panels over time due to the deposition and adhesion of such substances to the PV glass surface [2]. However, how to obtain demineralised water is a critical issue that must be confronted. It can be produced, for example, by means of a reverse osmosis process applied to fresh water. This process normally implies water wasting (eluate) up to 50% of the whole treated liquid, in order to minimize electrical consumption.

Increasing shortage and pollution of fresh water traditional sources, as underlined in the United Nations World Water Development Report [4] and highlighted also in the Special Report on Climate Change and Land [5], should be alarming enough to prompt the search for other solutions in order to obtain demineralised water. Moreover, even if a photovoltaic field is placed in an area not affected by water scarcity or stress, the availability of such a resource can suddenly change in case of drought in particular or unexpected emergency conditions.

UNICEF reported that "around 74 per cent of natural disasters between 2001 and 2018 were water-related including droughts and floods. The frequency and intensity of such events are only expected to increase with climate change".

Another factor that must be taken into account is the water price, which in many countries has been maintained artificially low for equity reasons. However, such a policy is no longer sustainable, due to increasing water needs and water scarcity, because it leads to high inefficiency in water usage. Thus, it is reasonable to consider the fact that water price is expected to increase in the next years, in particular when its use is not strictly related to human consumption.

An alternative source of cleaning water can be seen in desalinated sea water. However, residual salinity is composed of chlorine compounds, which makes it not very suitable for panel cleaning because such substances can strongly affect panel and electrical circuit integrity. Moreover, the disposal of brine (the eluate) represents a critical issue for desalinisation sustainability, brine can be heavily polluted and could require a specific treatment, in particular if the eluate comes from sea water through reverse osmosis, as it may contain not only a very high salinity ratio but also other chemicals involved in the desalinisation process. A sustainable approach in photovoltaic panel cleaning should avoid not only traditional fresh water reservoir depletion but also brine creation and water pollution due to chemicals use.

It must also be underlined that areas with the highest radiation levels are often located in desert regions, are very far from traditional water sources, and are characterised by lack of rainfall. M.Z. Al-Badra stated that in those areas there are large-sized solar panel plants, and M. Saidan added that such panels are affected by high dust accumulation. As noted by H.A. Kazem, this can be due to the critical environmental conditions in the surroundings. In such places, water scarcity and unsteady supply are issues to confront, without forgetting possible social conflicts arising from arbitration on water different uses.

Water coming from humidity condensation is naturally poor in salts content, thus, it can be directly used in panel cleaning, without an osmosis stage or any other particular filtration technique, except for a mild microbiological treatment, such as a UV lamp disinfection, in order to avoid mould and fungi growth. The AWG-produced water, in comparison to the condensate coming from air conditioning or heat pumps, is purer, even if not particularly treated; this is because of the particular materials employed in the condensation section, which must be certified as suitable for coming into contact with drinking water.

There are two more issues that are linked to one another: the fact that an AWG system has not a constant water production during the year, and the fact that producing water requires energy (related to the condensation process and air fans). Such energy consumption is variable and is related to water production. As a matter of fact, each AWG

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system, independent from the implemented technical solution employed in moisture condensation from environmental air, has a variable efficiency in terms of water production and energy consumption; this efficiency strongly depends upon the thermodynamic and hygrometric air state, i.e., from weather conditions. In effect, as relative humidity and temperature increase, extracted water is more abundant and requires less energy; if the climate is dry and/or cold, the yield lessens and energy consumption increases.

Moreover, the solar field efficiency without cleaning drops by 27% after 145 days. This means that the energy loss in a not cleaning scenario is valued may be even worse because the studies stops after 145 days, and 27% has not yet been determined as the regime value. On the contrary, the energy loss in the cleaning configuration, is only 4.6% of the expected average daily production, which means 83% of energy loss saved.

The produced water influences the number of required machines to cover the clean- ing needs, and the energy efficiency strongly influences the energy cost of each litre. The higher the specific energy for water production, the higher the period is between one cleaning operation and the other, and thus the higher the energy losses due to dirt accu- mulation. On the other side, a higher number of machines increases the investment cost and thus affects in an indirect way the cleaning frequency, which is likely to increase.

Reference

1. Sarver, T.; Al-Qaraghuli, A.; Kazmerski, L. Comprehensive Review of the Impact of Dust on the Use of Solar Energy: History, Investigations, Results, Literature, and Mitigation Approaches. *Renew. Sustain. Energy Rev.* **2013**, *22*, doi:10.1016/j.rser.2012.12.065.
2. Kazem, H.A.; Chaichan, M.T.; Al-Waeli, A.H.A.; Sopian, K. A review of dust accumulation and cleaning methods for solar photovoltaic systems. *J. Clean. Prod.* **2020**, *276*, 123187, doi:10.1016/j.jclepro.2020.123187.
3. Appels, R.; Lefevre, B.; Herteleer, B.; Goverde, H.; Beerten, A.; Paesen, R.; De Medts, K.; Driesen, J.; Poortmans, J. Effect of soiling on photovoltaic modules. *Sol. Energy* **2013**, *96*, 283–291, doi:10.1016/j.solener.2013.07.017.
4. UN-WWAP. *The United Nations World Water Development Report 2015: Water for a Sustainable World*; UN-WWAP: Paris, France, 2015.
5. Special Report on Climate Change and Land. Available online: https://www.ipcc.ch/srccl/ (accessed on 12 April 2021).
6. UNICEF stories, Water and the Global Climate Crisis: 10 Things You Should Know. Available online:https://www.unicef.org/stories/water-and-climate-change-10-things-you-should-know (accessed on 12 April 2021).